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WESTERN SPRUCE BUDWORM POPULATION DENSITIES AND DEFOLIATION ONE YEAR AFTER INSECTICIDE TREATMENT OF SMALL BLOCKS

by

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ABSTRACT

The insecticide Orthene (acephate) was sprayed on a series of 1000-acre blocks in central Idaho during 1977, resulting in high mortality of western spruce budworm and foliage protection. One year later larval numbers in treated blocks were only one-third the level found in untreated blocks, and defoliation in treated blocks was one-fourth of that found in the untreated blocks. The mechanisms responsible for these differences are not fully understood. The observations reported here suggest that spray blocks as small as 1000 acres may be protected for more than a single season from defoliation, and show the need for monitoring of insect populations and resultant defoliation for a minimum of one field season after treatment.

INTRODUCTION

Two major chemical control strategies are practiced in North America to reduce effects of spruce budworm outbreaks. In eastern Canada, insecticides are applied sequentially to early instars of the eastern spruce budworm, Choristoneura fumiferana (Fettes and Buckner 1976). In the western United States, late larval instars of the western spruce budworm, Choristoneura occidentalis, are treated with a single application of an insecticide to reduce populations as much as possible. The latter strategy sacrifices new foliage, but provides a larger, more exposed target. Several years' reduction of the population can be achieved, and in some cases the outbreak may be terminated.

Regardless of strategy, pest managers and resource managers must first decide whether budworm infestations should be treated with an

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insecticide. This decision requires an evaluation of cost vs. benefits. Cost includes price of material, application, administration, and risk of adverse environmental impacts. A cost that is not obvious but must be considered is one associated with retreatment. If retreatment is necessary, how often will a population on a specific site have to be retreated--the next year, in two years, or not at all? It is often assumed in the Western United States that unless an entire infestation is treated, reinvasion will occur and retreatment will be necessary the next year or several times during a population outbreak; and that after treatment, small areas (1000-3000 acres) of infested timber will be reinvaded by moths.

This paper documents a series of observations in which reinfestation did not occur and reviews some earlier studies that indicate retreatment was not necessary. Whether retreatment was unnecessary because reinvasion did not occur or whether the population surviving treatment failed to resurge is not known.

EARLY STUDIES

Johnson and Denton (1975) reviewed the history of western spruce budworm outbreaks in the northern Rocky Mountains and aerial application of insecticides from 1952-1972 in Idaho, Montana, and Wyoming. From 1952 to 1964 DDT applied at the rate of 1 lb. A.I./gal./acre was most often used for suppression of western spruce budworm. The Bitterroot National Forest in Montana was treated with DDT in 1952, 1955, and 1959. Treatment using DDT on the Helena National Forest in Montana followed a similar pattern--the Forest was first treated in 1953, and again in 1956 and 1962. In eastern Oregon, DDT was also used to suppress western spruce budworm populations beginning in 1948 and ending in the late 1950's. Less than 1 percent of the areas treated there once with DDT required retreatment during the same infestation cycle (Whiteside 1958).

In 1976, 6000 acres of infested Douglas-fir in the State of Washington were treated with 1 lb. of Sevin 4-oil per acre. Population reduction averaged 96.2 percent (Anon. 1977). In 1977 and 1978, data on egg mass trends and larval populations showed that western spruce budworm populations remained low in treated areas and relatively stable in adjacent untreated areas. A similar situation was noted in Montana, where after aerial application of *Bacillus thuringiensis*, treated areas appeared "greener" than the adjacent untreated stands the following year[5].

Effectiveness of insecticides for more than one season is also documented in northern New Mexico. Sevin 4-oil was applied at 1 lb. A.I./0.5 gal./acre during the summer of 1977 to late larval instars of western spruce budworm, resulting in an average population reduction of 93.1 percent (Parker *et al.* 1978). Subsequent sampling of egg masses

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and larval stages in 1978 show that treated areas continue to have significantly lower populations than untreated areas (Parker *et al.* 1979).

RECENT STUDIES

In 1977 a pilot control project was conducted to evaluate operational effectiveness of Orthene (acephate; manufacturer, Chevron Chemical Company) for control of western spruce budworm. This project was a cooperative effort of the Idaho Department of Lands and the Forest Service's Intermountain Region (R-4). Eight 1000-acre spray blocks were established in infested stands of Douglas-fir, *Pseudotsuga menzeisii*, and grand fir, *Abies grandis*, northwest and southeast of McCall, Idaho, on the Payette National Forest and on Boise Cascade Corporation land. Four blocks were randomly selected for treatment and the other blocks served as untreated checks. A Bell 206B helicopter applied the chemical at the rate of 0.5 lb. A.I./gal./acre. Budworm larval population reduction due to the treatment was high (90 percent-plus) and foliage was protected (Stipe *et al.* 1979).

The following studies provide data on insect populations and resultant defoliation one year following treatment.

FLIGHT OF ADULT MALES

A study was done to determine rate and pattern of invasion of male western spruce budworm into treated plots[6]. Individual males were trapped in two blocks [Four Mile Creek (Block #1) and Stover Creek (Block #4)] that had been treated with 1/2 lb./acre Orthene, and in an untreated plot [Brown Creek (Block #6)].

A 1000- by 1000-foot grid was placed over a map of each of the three blocks and extended beyond the block boundary by 2000 ft.. In each block, 70 sample points and 10 alternates at grid intersections were randomly chosen. Each tentative sample point was visited, and those found to be over 1000 ft. from a usable road, in a cut over area, or over 200 ft. from suitable host type were discarded and replaced with one of the alternate sample points.

Distance from each sampling site to the nearest plot boundary was measured and used to place the sampling site into one of six categories. Three categories were inside the plot boundary at 1000 ft., 2000 ft., and 3000 ft.; one was for traps that fell within a few hundred feet of the boundary itself; the other two were for traps that fell at 1000 ft. and 2000 ft. outside the plot. Grid design and placement of sampling

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6 The study was jointly directed by G.P. Markin, Pacific Southwest Forest and Range Experiment Station, Davis CA; L. Livingston, Dept. of Private Lands, State of Idaho, Coeur d'Alene, ID; G. Daterman, Pacific Northwest Forest and Range Experiment Station, Corvallis, OR; and Don Curtis, FI&DM, Ogden, UT.

sites into six categories were used on the two treated blocks and the one untreated check (table 1). For each sampling interval the catch in all traps in each category was averaged (figs. 1-3).

Special pellet baits were prepared with a low dosage of western spruce budworm pheromone so that the attractive radius per baited trap would be less than 100 ft. under normal field conditions. At each sample point a pheromone-baited disposable sticky trap was placed 6 ft. above the ground in a grand fir or Douglas-fir sample tree. Each trap was left out for three days, collected, and replaced with a fresh trap. Traps were opened in a field laboratory and the number of male budworms counted.

The first set of traps, in place by July 18, indicated that emergence had begun. Subsequent traps were replaced at three-day intervals until about August 4. Moths caught in large numbers and monitoring of pupae indicated that most emergence had taken place by that date.

One interpretation of these data is that treated blocks produced fewer males than untreated areas. Because of this difference, the initial trap catch within blocks was lower than catches outside of the blocks or within the check block. However, between July 26 and 29 a migration of moths into treated blocks from outside occurred, and subsequent trap catches within the blocks were in the same general range of those outside the block. From these data, we concluded that western spruce budworm males can move up to 3000 ft., or that there was adult emergence in the vicinity of the trap.

EGG MASS SURVEYS

Egg masses were sampled from Orthene-treated blocks and untreated check blocks during the last two weeks in September 1977. Twenty-five clusters of three codominant Douglas-fir were sampled by taking two mid-crown branches from each tree (Grimble and Young 1977). The 70-cm sample branches were bagged separately and transported to a temporary field laboratory where egg masses were counted.

Results of the egg mass survey indicated moderate to heavy defoliation would occur in treated as well as check blocks during 1978. Comparison of data on treated and untreated egg masses from the eight blocks showed no difference among the three foliage measurement procedures, i.e., length x width, grid area, and egg masses per branch (table 2). At the time of sampling, all indications pointed to reinfestation of the four Orthene-treated blocks by female western spruce budworms. These indications tend to support data from the pheromone traps, suggesting a high level of adult activity in the spray blocks after treatment.

Table 1. Pheromone traps at each sampling location within the three study blocks.

Block no.	Mean larval ($\pm$S.E.) population[1]	Distance inside block (ft) 3000	2000	1000	Block boundary	Distance outside block (ft) 1000	2000
4 (Stover Creek)	1.8 ± 0.5	7	10	15	17	14	7
1 (Four Mile)	2.5 ± 0.6	5	9	17	12	14	13
6 (Brown Creek)	68.3 ± 4.9	2	8	18	12	17	13

1 Mean number (and S.E.) of budworm larvae per 100 new buds in blocks 10 days following treatment (from Stipe *et al.* (1979).

Table 2. 1977 western spruce budworm egg mass densities and predicted 1978 defoliation.

	Egg masses per square meter				Egg masses per branch		Defoliation class predicted for 1978
	Length x width method		Grid area method				
Block no.	Mean	S.E.	Mean	S.E.	Mean	S.E.	
TREATED							
1 (Four Mile)	1.9	.4	1.5	.3	.4	.1	moderate
2 (Brundage)	2.6	.5	1.7	.3	.6	.1	moderate
3 (Boulder)	9.5	1.7	7.1	1.2	1.9	.2	heavy
4 (Stover Cr.)	6.4	1.0	5.0	.8	1.3	.3	heavy
AVERAGE	5.1	1.8	3.8	1.4	1.1	.3	heavy
UNTREATED							
5 (Little Goose Cr.)	2.6	.5	2.3	.4	.5	.1	moderate
6 (Brown Cr.)	7.1	1.4	4.8	.7	1.7	.3	heavy
7 (Paddy Cr.)	4.7	1.4	3.4	.8	.9	.3	moderate
8 (Rapid Cr.)	10.4	1.6	8.0	1.3	2.2	.4	heavy
AVERAGE	6.2	1.7	4.6	1.2	1.3	.4	heavy

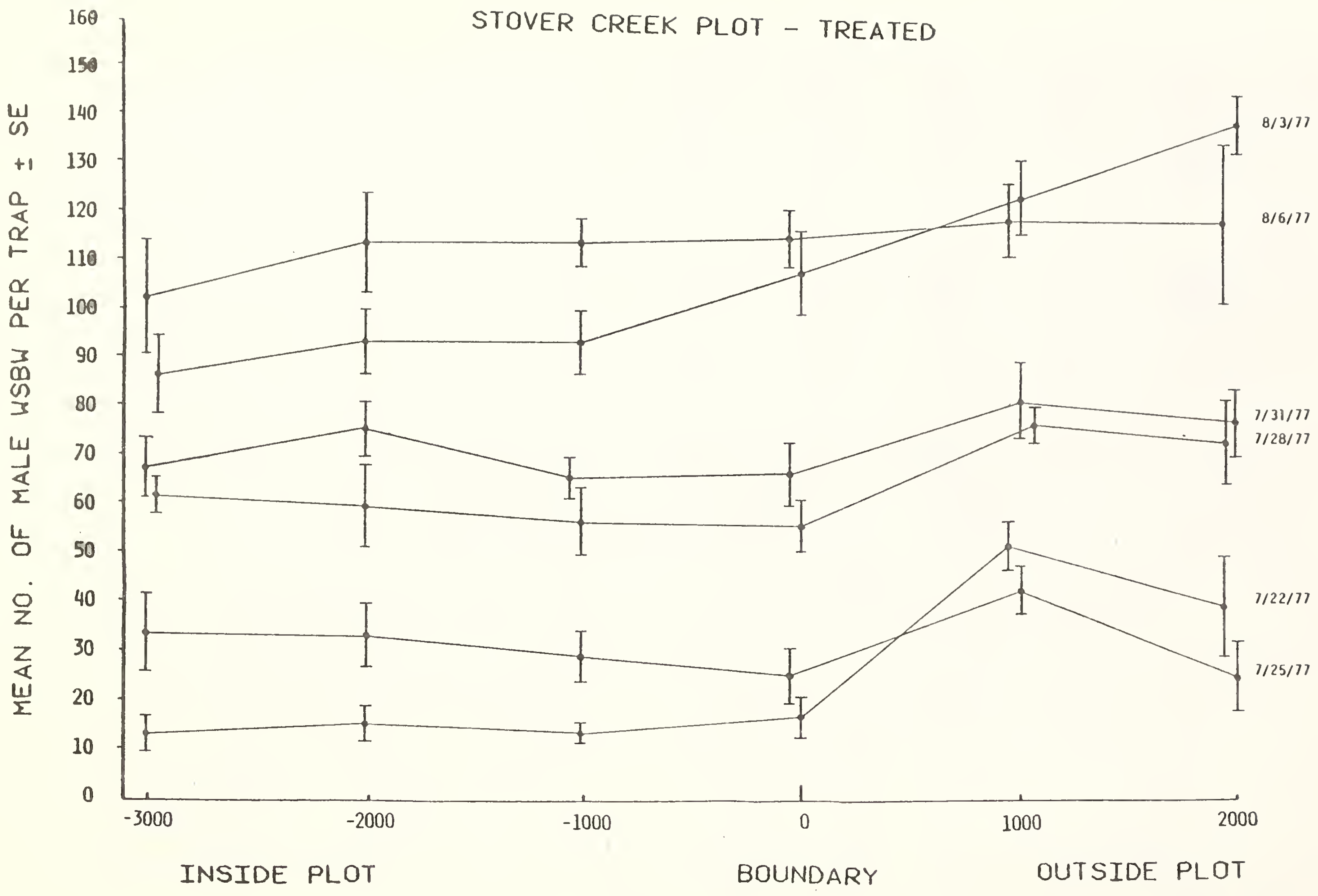

Figure 1. Summary of western spruce budworm male moth catches in pheromone traps, Stover Creek pilot project block, 1978.

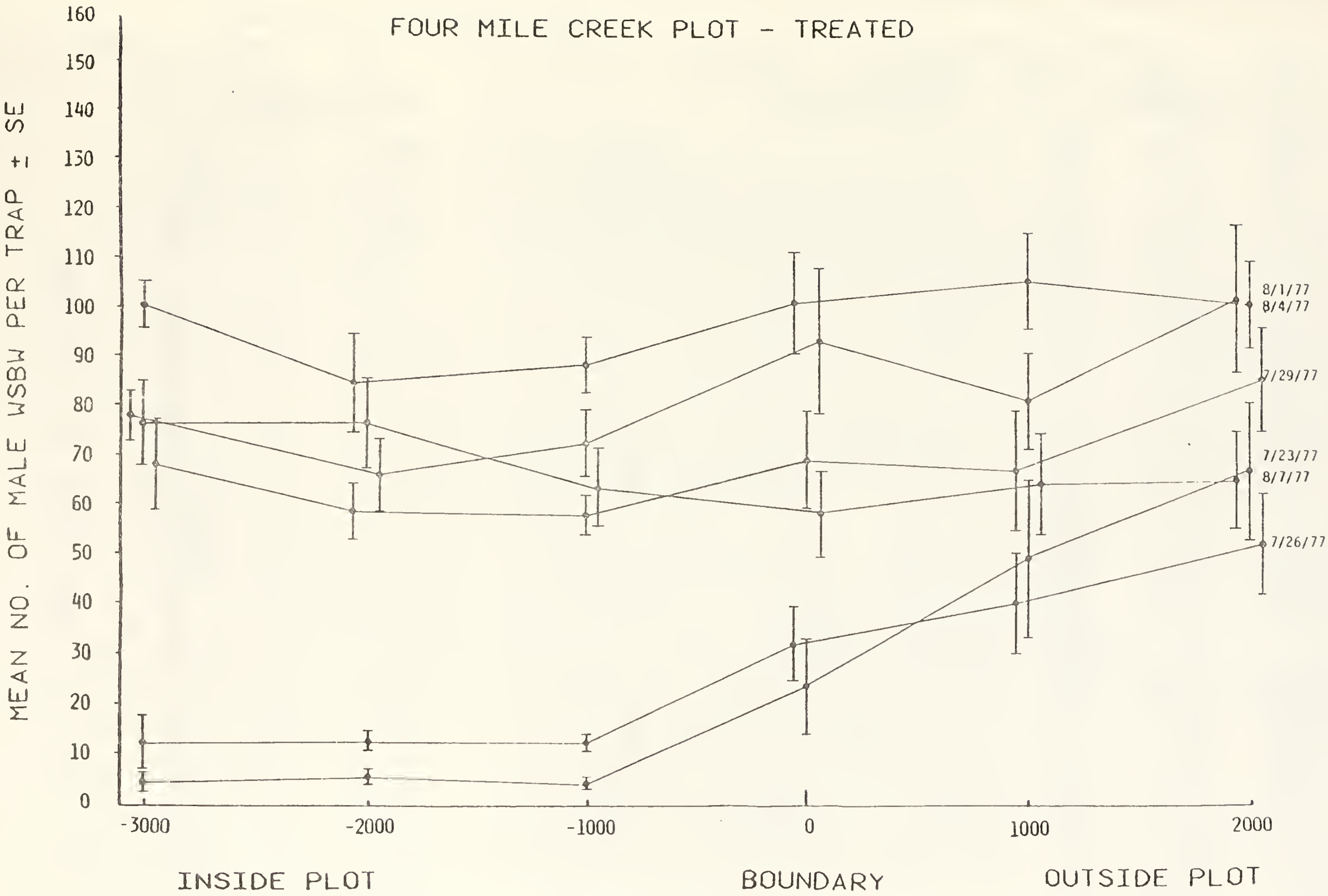

Figure 2. Summary of western spruce budworm male moth catches in pheromone traps, Four Mile Creek pilot project block, 1978.

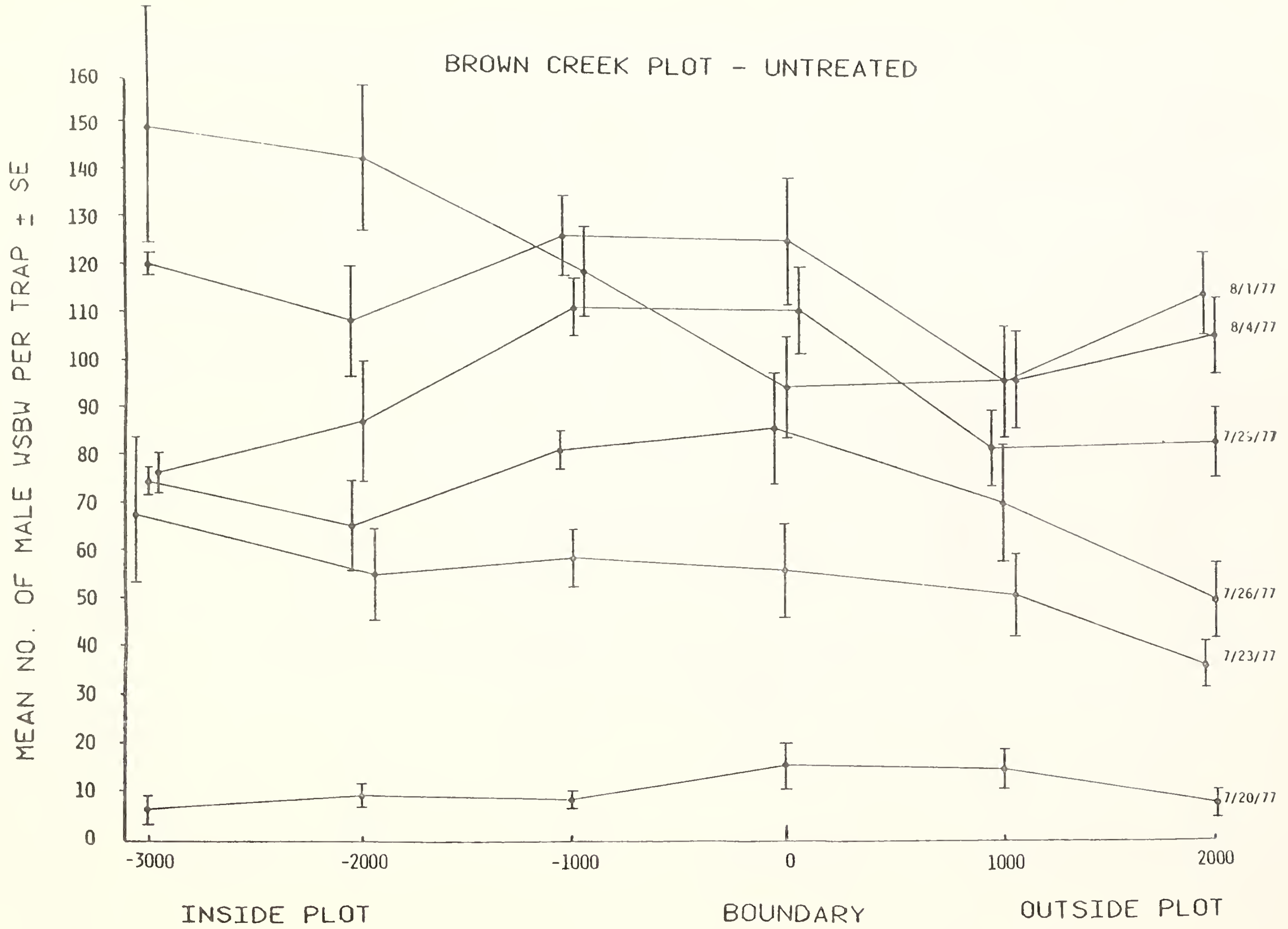

Figure 3. Summary of western spruce budworm male moth catches in pheromone traps, Brown Creek pilot project block, 1978.

POPULATION DENSITIES AND DEFOLIATION

Each of the eight blocks were visited on July 22, 1978. Five sample grand firs, each between 30 and 60 ft. tall, open grown, and separated by a minimum of 250 ft., were selected in each of three sample areas per block for a total of 15 sample trees.

Four 15-inch branch samples were collected from mid-crown of the sample trees and transported to the field laboratory, where larvae and pupae were counted. Larval population estimates, which included a few pupae, were expressed as numbers of larvae/100 new shoots.

Defoliation was estimated by the method of Grimble and Young (1977): each new shoot was examined and placed into one of four categories, and the values averaged to estimate mean defoliation per branch.

Population levels in 1978 in the eight were compared with 1977 population levels (table 3). The data are not directly comparable, however, since 1978 samples were taken on July 22, while the 1977 post-10-day samples were collected between July 4 and July 9; i.e., larval populations in the 1978 samples had 13-18 more days of natural mortality before they were sampled.

Defoliation estimates were made in 1977 and 1978 (table 4). The 1977 defoliation estimates were made 10 days after spray, between July 4 and 9. In 1978 the trees had suffered an additional 13-18 days of defoliation before they were sampled. Also, 1977 was drier than 1978, a wet year in which trees had more shoot growth. Because of these differences, comparisons of defoliation comparisons should be made cautiously.

No direct correlations can be drawn between larval population levels and resultant defoliation between 1977 and 1978, although it appears that both were lower in 1978 on all plots. However, the population in the treated blocks was one-third the level of that found in check blocks in 1978, and defoliation was one-fourth. Therefore, it appears that populations and defoliation remained quite low in the treated blocks during 1978.

AERIAL ASSESSMENT OF DEFOLIATION

An aerial reconnaissance survey in early August 1978 confirmed earlier ground observations that the Orthene-treated spray blocks had lower intensities of defoliation than did the untreated stands.

Oblique photographs were taken at 700 to 1000 ft. above the terrain on August 1 and 3. Only the Stover Creek and Four Mile blocks were photographed. Two cameras, a Nikon F2S 35mm equipped with an 85mm lens, and a Hasselblad EL 70mm with an 80mm lens, were used. Two films, Kodak Kodachrome 64 and Aerochrome color infrared (2443), were exposed with the 35mm camera. Ektachrome color film was exposed with the 70mm camera.

Table 3. Population levels of western spruce budworm larvae (larvae/100 new shoots) for eight pilot project blocks near McCall, Idaho, 1977-78.

Block no.	Pre-spray 1977[1] Mean	Pre-spray 1977[1] S.E.[2]	10-day post-1977[1] Mean	10-day post-1977[1] S.E.	1978 Mean	1978 S.E.
TREATED	- - - - - - - - - -	- - -	number of larvae	- - -	- - - -	- - - -
1 (Four Mile)	37.2	3.1	2.5	.6	.7	.2
2 (Brundage Mtn.)	20.0	2.4	3.2	.7	1.8	.5
3 (Boulder Cr.)	43.1	4.0	4.1	.8	3.3	.7
4 (Stover Cr.)	29.2	3.0	1.8	.5	7.0	2.1
AVERAGE	32.4	5.0	2.9	.5	3.2	1.4
UNTREATED						
5 (Little Goose Cr)	33.6	3.7	24.7	3.0	13.5	2.7
6 (Brown Cr.)	35.9	3.0	19.1	2.0	6.6	1.2
7 (Paddy Cr.)	20.2	2.2	12.6	1.4	8.2	1.5
8 (Rapid Cr.)	19.5	2.5	13.8	2.6	9.1	1.8
AVERAGE	27.3	4.3	17.6	2.8	9.4	1.5

Table 4. Defoliation estimates for treated and check blocks, in 1977 and 1978.

Block no.	Defoliation[1] July 1977 Mean	Defoliation[1] July 1977 S.E.[2]	Defoliation[1] July 24, 1978 Mean	Defoliation[1] July 24, 1978 S.E.[2]
TREATED	- - - - - - - - - -	- - - percent	- - - - -	- - - - -
1 (Four Mile)	52.0	4.0	2.4	.8
2 (Brundage Mtn.)	49.6	5.1	5.5	1.2
3 (Boulder Cr.)	74.3	5.7	16.8	1.8
4 (Stover Cr.)	52.5	5.0	15.3	1.8
AVERAGE	57.1	5.8	10.0	3.6
UNTREATED				
5 (Little Goose Cr.)	66.1	5.5	49.8	5.2
6 (Brown Cr.)	68.3	4.9	32.8	3.7
7 (Paddy Cr.)	50.1	3.9	20.3	3.5
8 (Rapid Cr.)	51.6	5.1	53.7	7.9
AVERAGE	59.0	4.8	39.2	7.7

1 Source: R.W. Young. 1977, USFS-FI&DM/MAG, Davis, CA. (unpublished report).

2 Standard errors (S.E.) shown for each block are the within-block sampling error; those for the averages are based on the four-block averages.

Both color and color IR oblique aerial photos recorded differences in defoliation roughly corresponding to block boundaries, with defoliation less intense in the spray blocks. On the Stover Creek block the most conspicuous difference occurred along the southern boundary, but differences in intensity of defoliation were noticeable on all boundaries. This was also true on the Four Mile block. Of particular interest on the Four Mile block was an area where the spray pilot extended spray swaths outside the established block boundary along its northern border (fig. 4).

CONCLUSIONS

In the West insecticides sometimes are aerially applied for control of western spruce budworm. Many resource managers believe that reinfestation occurs by moths migrating from adjacent untreated forests, necessitating retreatment within 1-2 years, or by population resurgence. Studies described in this paper indicate that while adult moth activity following treatment was as great as in untreated blocks, larval populations and resulting defoliation 1 year later were substantially less. Information on reinvasion is insufficient to explain the differences observed, but the limited evidence suggests that a single treatment of Orthene resulting in high larval mortality caused reduced larval numbers and defoliation the following year. If it can be established that two or more years' protection can routinely be expected to result from a single application, significantly increased benefits could be projected from such programs.

We recommend that in future pilot and operational projects budworm populations and resultant defoliation be monitored for at least one season after treatment. Also, research leading to a better understanding of reinfestation rate and conditions under which it occurs should be emphasized.

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Figure 4. Aerial view of Four Mile Creek spray block taken in July 1978, looking north. Note general lack of foliar injury on lower half of photo and sharp line of demarkation on ridge where foliar injury is evident.

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